THE BIONOMICS OF TABANID LARVAE (DIPTERA)[1]

BY

NAWAB H. KHAN, M.SC. (ALIG.), PH.D. (MASSACHUSETTS), F.R.E.S.
Department of Zoology, Muslim University, Aligarh

(*With two plates*)

Tabanids constitute one of the most important groups of insects from the agricultural as well as the medical point of view. They not only suck the blood of man and livestock and reduce their working hours, but also transmit serious disease pathogens among man and his domesticated animals. With the exception of mosquitoes, they are undoubtedly the most important of all the blood-sucking insects. But in spite of all their importance very little has been accomplished so far, with respect to their bionomics.

The present paper deals with the various methods which have been employed for collecting and rearing the tabanid larvae together with some original observations. The author has described the movements of tabanid larvae in the soil and has observed the effects of various ecological factors on their population.

The larvae of Tabanidae are characterised by eleven body segments, in addition to head and siphon. The small retractile head is provided with strong mouth hooks, which are adapted for piercing and extracting the contents of their prey. The cylindrical body tapering at both ends has a shiny transparent striated integument through which the principal body viscera are usually visible. The siphon bearing the opening of the respiratory system at the end of the anal segment is capable of retraction and extension. The general coloration is variable. It may be white, white tinged with green or pink, greenish gray, brownish yellow, or chlorophyll green.

The larvae are either saprophagous or carnivorous or both. They are very efficient in penetrating the soil, and their great power of crawling through small and narrow spaces is very noticeable. They exhibit strong negative phototropism.

Ecologically the larvae inhabit hydrophytic, mesophytic or lotic areas. Though some species having well-developed tracheal trunks can float on water, a great majority of them burrow in the soil or mud soon after hatching. The feeding period lasts from the time of hatching until the approach of winter. During winter the larvae cease feeding and hibernate. With the oncoming of spring, they again renew feeding and after a time pupation may result. The feeding

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time is variable, different with different species and even within the same species.

Collection: Various methods have been used by different workers for the collection of tabanid larvae. Collection is often difficult, either because of their wide and varied distribution or because the larvae are not abundant in the locality under investigation. This, however, becomes comparatively easy with experience. Marchand (1917) advocated his 'sieve method' in which a lump of mud from a suitable locality is taken into a sieve and gently shaken in water. The soil is thus washed out and the larvae exposed. Cameron (1926) and Philip (1928) used a hand fork and horticultural weeder respectively. The method consisted in turning over the soil and thereby exposing the larvae. A group of workers including Stammer (1924), Logothetis and Schwardt (1948), and Tashiro and Schwardt (1949), have recommended the transportation of mud from infested areas and recovering the larvae in the laboratory by drying.

The present work was started with the sieve method and at first a spade was used for digging. Digging with a spade was soon discarded in favour of a hand trowel. This made the work easier and gave as good or better results. The procedure consisted in cutting the vegetation from the selected areas, each area being one square foot, digging a few inches (4-6) deep, and placing the soil in a sieve. The sieve was then gently shaken in water to wash off the mud. During this shaking the big larvae were easily detected and picked up with a forceps. They were placed in suitable tin containers and brought back to the laboratory. Often the larvae were tangled in the roots of the plants. The method is quite satisfactory for collection if a small number of larvae are desired and the collector is quite sure of their distribution, but has its greatest drawback in being time consuming.

Another method consisted in the use of pyrethrum-kerosene emulsion called 'New Jersey mosquito larvicide' on the lines suggested by Bailey (1949), who used it as a means of his mass collection and population survey of tabanid larvae. Bailey diluted the concentrate seven to eight times with water and after cleaning away surface vegetation applied two gallons of the mixture to five square yards. The larvicide used by the author contained 65% of active ingredients composed of petroleum distillate, sodium lauryl sulfate, thiodiphenyl amine and pyrethrins. The vegetation was cleared with a hand sickle and the emulsion, diluted from one to eight to one to twelve, was applied to square foot areas at the rate of one gallon to four or five square feet.

Within two to five minutes a number of organisms, including the tabanid larvae, came to the surface. Ten areas were observed at a time and the larvae collected with a forceps as they appeared. The retreating of the larvae from the mud was produced by the pyrethrum. Such larvae were paralysed after their appearance on the surface.

The ease and effectiveness of the above method for collecting the larvae in making population surveys suggested its use for collection of larvae for rearing purposes. The larvae as they appeared were immediately transferred to untreated mud, brought back to the laboratory and placed in separate cans with food. Larvae collected by the 'sieve method' were handled similarly as checks (Table 1).

TABLE 1

EFFECT OF 'NEW JERSEY MOSQUITO LARVICIDE' ON LARVAE

Number of larvae	Number dead after 25 hours	Number survived ten days	Percentage survival
40 (treated) ...	23	17	42·5
10 (Untreated) ...	0	10	100·0

Since 42.5 per cent of the treated larvae appeared normal after ten days this seems to be a satisfactory method of collecting larger larvae for rearing studies. During the test the smaller larvae were more susceptible to the insecticide. Adults of *Tabanus quinquevitattus* and *T. lineola* were reared from the larvae thus collected.

The larvicide was used successfully with dilution of 1 :14. At a dilution of 1 : 19 only one larva was collected in 20 sq. ft., but as stronger concentrations were not used to determine if the larvae were missed due to greater dilutions of the insecticide, any precise statement regarding the inefficiency of the dilution cannot be made.

M o v e m e n t s in S o i l: Except for occasional references stating their wide and varied occurrence a few inches deep in the soil, very little is known regarding the movements of tabanid larvae. Segal (1936) states that *Chrysops* larvae occur about two inches deep in the soil near the edge of any permanent pond in New York (U.S.A.). The writer has made preliminary surveys to determine the prevalence and distribution of larvae in the soil. Square foot samples of mud to a depth of 1 to 1.5 inches were placed separately in collection funnels shown in Figure 1. The larvae, if any, dropped into the bottles containing water, below the funnel openings. Two 60-watt bulbs were fixed inside each funnel for drying the mud. The samples of mud completely dried within three to four days, and no larvae were collected after four days of drying.

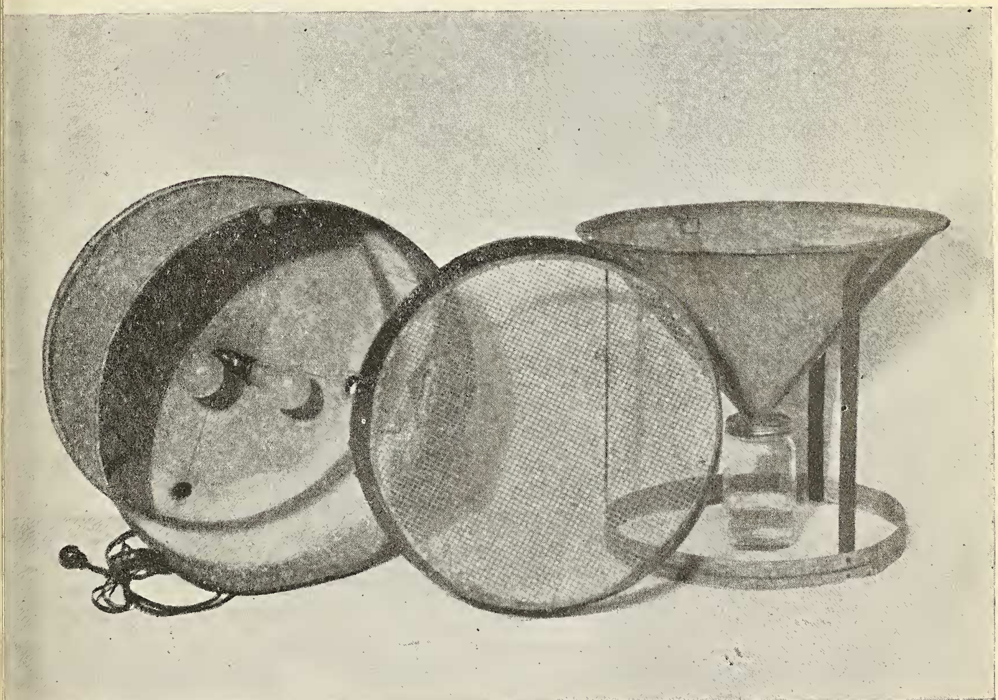
After collecting the mud from the selected areas, the spots were sprayed with pyrethrum-piperonyl butoxide emulsion having a dilution of 1 :14, to find if any larvae were present below the mud collected (Table 2).

TABLE 2

OCCURRENCE OF TABANID LARVAE WITH REFERENCE TO DEPTH

No. of areas	No. of larvae in upper 1-1·5 inches	No. of larvae below 1·5 inches
100	52	15
Average larvae found per area ...	0·52	0·15

Funnel assembled



Funnel in parts

Fig. 1. Funnels used for obtaining larvae from the soil

The above findings have certain limitations. The depth at which the larvae occur would vary with different species, abundance of food in the habitat, and weather conditions. All species would probably move downward during winter when the upper layers become frozen, as the larvae 'cannot survive in frozen soil, at least if it is moist.' (Stone, 1930). The behaviour of different species was significant. While most species were present within 1-1.5 inches depth, *T. atratus* always occurred below that depth. As for food, no generalization can be made. It seems that if the species is saprophytic, the food within the above limits would be abundant, but if predaceous it might have to move downwards, due to lack of sufficient food within the above limits.

The distribution of tabanid larvae at varying distances from the edge of the water bodies varies according to the species. Logthetis and Schwardt (1948) found numerous larvae of *T. viscaris* (*costalis*) in pastures and meadows, while Gerry (1948) reports the presence of 94% of the larvae of *T. nigrovitattus*, a very abundant species within 200 feet of the upland. The writer sampled soil for larvae at varying distances in the field by the use of pyrethrum-piperonyl butoxide emulsion and 'New Jersey mosquito larvicide' after the manner described above. The results obtained are presented in Table 3.

TABLE 3

POPULATION OF TABANID LARVAE AT VARYING DISTANCES FROM WATER ALONG A BROOK

Distances from water-edge in feet	No. of areas tried	No. of larvae found	Average number of larvae per square foot
0–1	100	75	0·75
1–2	20	4	0·20
2–3	10	5	C·50
3–8	50	0	0·0
8–50	100	0	0·0

No larvae were found beyond three feet of the water's edge. One most probable reason for this absence beyond three feet was the low moisture content of soil in distant areas. This was further substantiated by the fact that even the larvae found within three feet of the water edge were present in areas presenting moisture contents very close to that in areas within one foot of the water.

To determine the influence of moisture on larval movements to a depth of 2 to 3 inches, soil was placed in a 11″ by 30″ terrarium in the laboratory. Varied moisture conditions were maintained by supplying sufficient water to wet the soil at one end. Leaves bearing the egg masses of *C. callida* and *T. atratus* were fixed in the terrarium so that the newly hatched larvae dropped on the mud. About twenty well-developed larvae were also placed in the container. Housefly maggots were supplied as food.

Observations were made after 4 months when it was found that only 18 larvae survived in the container, and this included 15 well-developed larvae and 3 small laboratory hatched ones. Thus, 3 out of some 3,000 to 4,000 newly hatched larvae of *C. callida* and *T. atratus* survived this period. There may be various reasons for the loss of the great majority of small larvae during the experiment. At the start, nearly the whole terrarium was saturated, or very nearly so, and this permitted larval movements all through the container. Later, as the moisture conditions became differentiated, the larvae moved toward the more favourable and moist portion until the low moisture content of the drier part inhibited any further migration. It is very likely that the smaller larvae in the dry portion could not withstand lack of moisture and died. Also the smaller larvae served as food for the bigger ones. (This predatory habit was demonstrated while recovering the larvae, as a large *Tabanus* larva was observed to attack and feed on a smaller *Chrysops* one.) What proportion of the young larvae succumbed to parasitism, or to other causes is unknown.

TABLE 4

FINAL POPULATION OF TABANID LARVAE IN TERRARIUM AFTER 4 MONTHS

Areas	Temperature		Percentage saturation of soil	No. of larvae collected
	Range	Average		
1	20·5—23°C	21·8°C	91·3	13
2	20·5—23°C	21·7°C	81·5	2
3	20·5—23°C	22·0°C	63·8	3

The results showed the effect of varying moisture content of the soil on the abundance of the larvae. This further confirms the above findings that tabanid larvae generally prefer a high moisture content of the soil. The presence of three well-developed larvae in the drier portion of the terrarium is self-explanatory, as well-developed tabanid larvae can survive for months under unfavourable environmental conditions.

Effect of ecological factors on Population: The effect of ecological factors on tabanid larvae presents an interesting and puzzling problem, as little has been accomplished by previous workers.

Undoubtedly biotic and physical factors influence the prevalence of larvae in the soil. Cannibalism as well as predatism is common among many species and reduce the initial population considerably. The larvae are generally predaceous, feeding on earthworms, available insect larvae, and the like. Several workers have also reported the

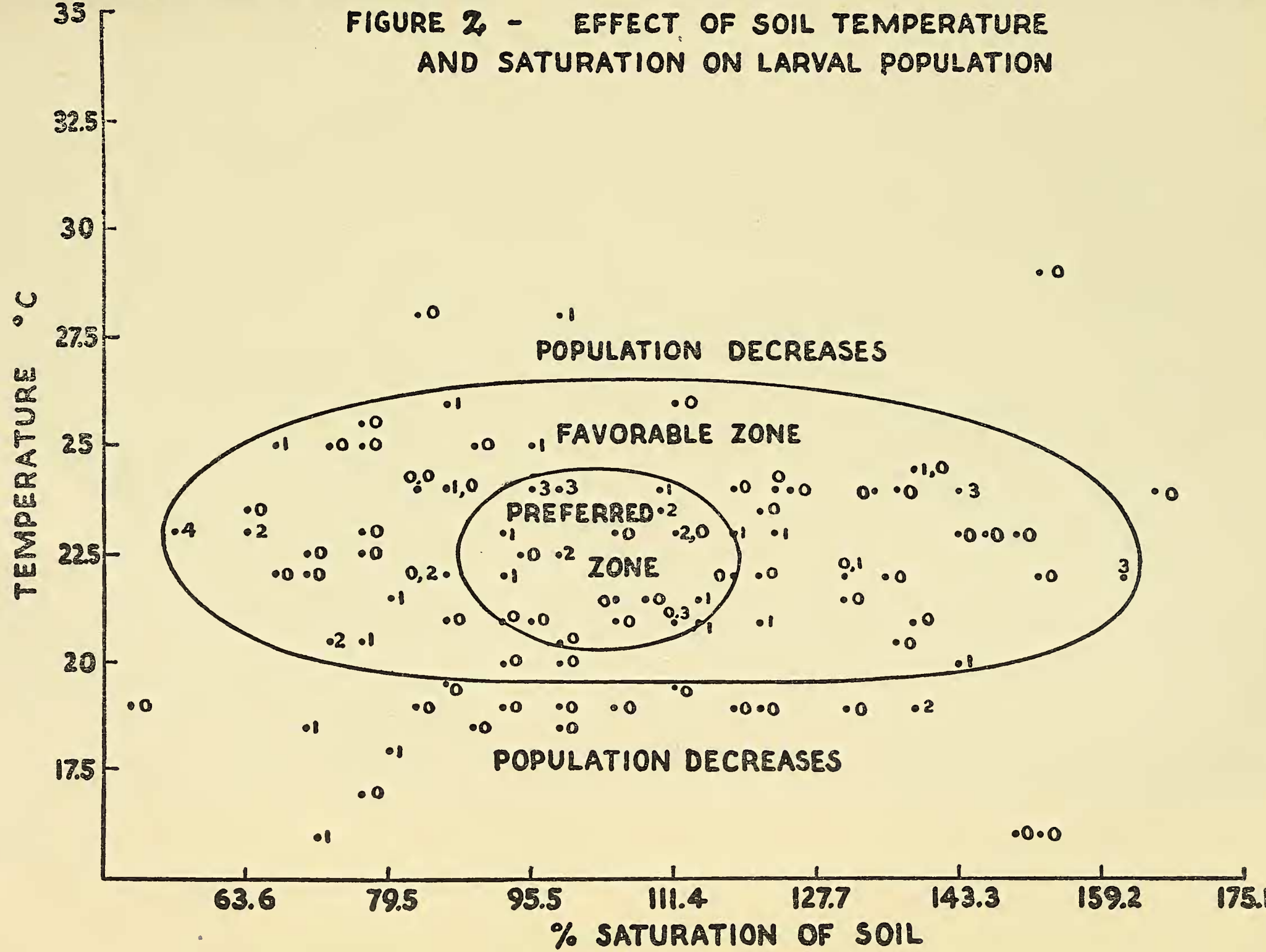


FIGURE 2 - EFFECT OF SOIL TEMPERATURE AND SATURATION ON LARVAL POPULATION
POPULATION DECREASES
FAVORABLE ZONE
PREFERRED ZONE
POPULATION DECREASES
TEMPERATURE °C
35
32.5
30
27.5
25
22.5
20
17.5
63.6
79.5
95.5
111.4
127.7
143.3
159.2
175.1
% SATURATION OF SOIL